Attorney's Docket No. 038190/274036 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.:	10/813,892	Confirmation No.: 5765
Applicant(s):	Comley et al.	
Filed:	03/31/2004	
Art Unit:	1725	
Examiner:	Kiley Stoner	
Title:	SUPERPLASTIC FORMING AND DIFFUSION BONDING OF FINE GRAIN TITANIUM	

Customer No.: 00826

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENT TO APPEAL BRIEF UNDER 37 CFR § 41.37 AND RESPONSE TO NOTIFICATION OF NON-COMPLIANT APPEAL BRIEF

This paper supplements the Appeal Brief filed August 11, 2006 in the application referenced above. Further, this paper responds to the Notification of Non-Compliant Appeal Brief, dated October 24, 2006.

The Notification of Non-Compliant Appeal Brief states that the Appeal Brief is defective for the following reason:

> Summary of claimed subject matter must identify and map all independent claims on appeal (16& 36) to specification by page and line number or paragraph number and to the drawings, if any.

Accordingly, Applicant is submitting this paper, including the following summary of the claimed subject matter, as a supplement to the Appeal Brief, as set forth in MPEP section 1205.03.

Summary of Claimed Subject Matter

Claim 1 is directed to a method for superplastically forming blanks to produce a first structural member having a predetermined configuration, e.g., the superplastically formed

structural member **10** illustrated in Figure 1 of the present application. *See* paragraph [0023]. The method generally includes providing a first and second blank comprising titanium and having a grain size of between 0.8 and 1.2 micron. For example, Figure 2 of the application illustrates a blank **12** supported between opposed dies **22, 24** of a forming apparatus **20** for forming the structural member of Claim 1. *See* paragraph [0024]. As set forth by Claim 1, each blank is heated to within a diffusion bonding temperature range of each blank, and the first blank is diffusion bonded to the second blank at a diffusion bonding temperature of less than 1450 °F. For example, Figures 3A and 3B illustrate an embodiment in which three sheets **10a, 10b, 10c** are provided in an apparatus **20a** with opposed dies **22a, 24a** that cooperatively define a die cavity **30a** therebetween, and the sheets **10a, 10b, 10** are diffusion bonded (e.g., to form diffusion bonds **54**) that define internal spaces that are inflated, such as in the formation of an expanded honeycomb structure. *See* paragraph [0025]. Claim 1 then recites that the bonded blanks are then heated to within a superplastic forming temperature range of the blanks, and superplastically formed at a forming temperature of less than 1450 °F to produce the structural member having the predetermined configuration. For example, as shown in Figure 3B, a pressurized fluid can be injected through tubes **32a** and between the sheets **10a, 10b, 10c** to inflate the pack and thereby superplastically form the sheets **10a, 10b, 10c**. Face sheets **10a, 10c** are superplastically formed against the respective dies **22a, 24a**, and the middle sheet **10b** is superplastically formed to a corrugated configuration as determined by the diffusion bonds **54** between the middle sheet **10b** and each of the face sheets **10a, 10c**. *See* paragraph [0025].

Per Claim 1, both the diffusion bonding and superplastic forming are therefore performed at temperatures less than 1450 °F, e.g., diffusion bonding at a temperature between 1400 °F and 1450 °F and/or superplastic forming at a temperature in this range (Claim 10). In fact, as described in the application, the fine grain titanium used in the present invention can be superplastically formed and diffusion bonded at temperatures less than those of conventional superplastic forming and/or diffusion bonding operations. In addition, the superplastic forming can generally be achieved at strain rates that are higher than the strain rates of conventional superplastic forming of titanium members. Thus, relative to conventional superplastic forming

of titanium members, the blanks **12** of the present invention generally can be formed at lower temperatures and faster forming rates. *See* paragraph [0031].

For example, the blanks can be superplastically formed at a strain rate of at least about 6 x 10^{-4} per second (Claim 11) or 1 x 10^{-3} per second (Claim 12). In this regard, Figure 6 illustrates the true stress and strain of exemplary structural members **10** during superplastic forming operations performed at four different temperatures according to embodiments of the present invention. In particular, Figure 6 is illustrative of flat sheet structural members that were superplastically formed under a tensile force at a strain rate of 3 x 10^{-4} per second. In separate trials represented by the lines **40**, **42**, **44**, **46**, the structural members **10** were formed at temperatures of 1400 °F (760 °C), 1425 °F (774 °C), 1450 °F (788 °C), and 1500 °F (815 °C), respectively. The true stress represents the force per unit of cross-sectional area of each structural member **10** perpendicular to the primary direction of elongation of the structural member. The true strain represents the elongation per unit length of each structural member **10** in the primary direction of the elongation of the structural member. The true strain is illustrated in Figure 6 along a logarithmic scale in which the true strain values in the graph are equal to the natural log of a ratio of the elongated size of the structural member to the original size of the structural member. That is, a strain value of 1.1 represents a strain of the structural member elongated by about 200% of its original length and a strain value of 1.8 represents a strain of the structural member elongated by about 500% of its original length. *See* paragraph [0031].

In some cases, the reduction in the forming temperature and time required for forming can reduce both the formation of oxides and a layer of alpha case on the structural member **10** during forming. In some cases, a layer of about 0.001 inch or less of alpha case is formed on the surface of the structural member **10** during superplastic forming (Claim 5). For example, Figure 5 illustrates the surface of the structural member **10** after superplastic forming, on which a layer **14** of about 0.0005 inch (13 micron) of the alpha case oxide was formed. The layer **14** of oxide material formed on the structural member **10** during superplastic forming can be removed using various chemical processes, such as by pickling, as recited in Claim 6. For example, the structural member **10** can be pickled by immersing the structural member **10** in a pickling fluid, such as nitric-hydrofluoric, comprising 40% nitric acid and 4% hydrofluoric acid, or otherwise

subjecting the structural member **10** to the pickling fluid, to remove the alpha case and oxide layer **14** formed on the structural member **10** during superplastic forming and/or diffusion bonding. *See* paragraph [0034]-[0035]. As set forth in Claim 8, the pickling step can remove less than about 0.001 inch from each surface of the structural member. *See* paragraph [0035]-[0036]. If opposite surfaces of the structural member **10** are pickled, the thickness of the structural member **10** can be reduced at a rate that is about twice the rate at which material is removed by pickling from each side of the structural member **10**. In some cases, the thickness of the structural member **10** can be reduced by less than about 0.002 inch (Claim 9) in order to substantially remove all of the oxide and alpha case formed on the surfaces during superplastic forming and/or diffusion bonding. Thus, the blank **12** can be superplastically formed to a thickness that is less than about 0.002 inch greater than a desired thickness of the structural member **10**. *See* paragraph [0035].

Such a pickling process can be used to remove the oxide layer **14** from the structural member **10** at a rate that is relatively slow relative to conventional chemical etching processes. For example, the structural member **10** can be dipped in or otherwise subjected to a pickling fluid that removes material from the surface of the structural member **10** at a rate less than about 0.001 inch per 20 minutes, i.e., less than about 5×10^{-5} inch per minute, as recited in Claim 7. In some cases, a reduced rate at which material is removed from the surfaces of the structural member **10** can increase the uniformity of the rate of removal throughout the surfaces of the structural member **10**. *See* paragraph [0036].

Independent Claim 16 is also directed to a method for superplastically forming a blank to produce a structural member having a predetermined configuration, and this method includes features of previously-described Claims 1 and 6. More particularly, Claim 16 is directed to a method for superplastically forming blanks to produce a structural member having a predetermined configuration, e.g., the superplastically formed structural member **10** illustrated in Figure 1 of the present application. *See* paragraph [0023]. The method generally includes providing a first and second blank formed of Ti-6Al-4V and having a grain size of between 0.8 and 1.2 micron. For example, Figure 2 of the application illustrates a blank **12** supported between opposed dies **22**, **24** of a forming apparatus **20** for forming the structural member of

Claim 16, (*see* paragraph [0024]), and the resulting structural member **10** can be formed of a titanium alloy that includes aluminum and vanadium such as Ti-6Al-4V with a refined structure (such as a grain size less than 2 micron, such as between about 0.8 and 1.2 micron) as shown in Figure 4 (*see* paragraph [0029]). As set forth by Claim 16, each blank is heated to within a diffusion bonding temperature range of each blank, and the first blank is diffusion bonded to the second blank at a diffusion bonding temperature of less than 1450 °F. For example, Figures 3A and 3B illustrate an embodiment in which three sheets **10a, 10b, 10c** are provided in an apparatus **20a** with opposed dies **22a, 24a** that cooperatively define a die cavity **30a** therebetween, and the sheets **10a, 10b, 10** are diffusion bonded (e.g., to form diffusion bonds **54**) that define internal spaces that are inflated, such as in the formation of an expanded honeycomb structure. *See* paragraph [0025]. Claim 16 further recites that the bonded blanks are heated to within a superplastic forming temperature range of the blanks, and superplastically formed at a forming temperature of less than 1450 °F to produce the structural member having the predetermined configuration, thereby forming a layer of alpha case oxide of less than about 0.001 inch thickness on each surface of the structural member. For example, as shown in Figure 3B, a pressurized fluid can be injected through tubes **32a** and between the sheets **10a, 10b, 10c** to inflate the pack and thereby superplastically form the sheets **10a, 10b, 10c**. Face sheets **10a, 10c** are superplastically formed against the respective dies **22a, 24a**, and the middle sheet **10b** is superplastically formed to a corrugated configuration as determined by the diffusion bonds **54** between the middle sheet **10b** and each of the face sheets **10a, 10c**. *See* paragraph [0025]. Figure 5 illustrates the surface of the structural member **10** after superplastic forming, on which a layer **14** of about 0.0005 inch (13 micron) of the alpha case oxide was formed. *See* paragraph [0034]. The layer **14** of oxide material formed on the structural member **10** during superplastic forming can be removed using various chemical processes, such as by pickling, as recited in Claim 16. For example, the structural member **10** can be pickled by immersing the structural member **10** in a pickling fluid, such as nitric-hydrofluoric, comprising 40% nitric acid and 4% hydrofluoric acid, or otherwise subjecting the structural member **10** to the pickling fluid, to remove the alpha case and oxide layer **14** formed on the structural member **10** during superplastic forming and/or diffusion bonding. *See* paragraph [0034]-[0035].

Independent Claim 36 is also directed to a method for superplastically forming a blank to produce a structural member having a predetermined configuration, and this method includes features of previously-described Claims 1 and 11. More particularly, Claim 36 is directed to a method for superplastically forming blanks to produce a structural member having a predetermined configuration, e.g., the superplastically formed structural member **10** illustrated in Figure 1 of the present application. *See* paragraph [0023]. The method generally includes providing a first and second blank formed of Ti-6Al-4V and having a grain size of between 0.8 and 1.2 micron. For example, Figure 2 of the application illustrates a blank **12** supported between opposed dies **22**, **24** of a forming apparatus **20** for forming the structural member of Claim 36, (*see* paragraph [0024]), and the resulting structural member **10** can be formed of a titanium alloy that includes aluminum and vanadium such as Ti-6Al-4V with a refined structure (such as a grain size less than 2 micron, such as between about 0.8 and 1.2 micron) as shown in Figure 4 (*see* paragraph [0029]). As set forth by Claim 36, each blank is heated to within a diffusion bonding temperature range of each blank, and the first blank is diffusion bonded to the second blank at a diffusion bonding temperature of less than 1450 °F. For example, Figures 3A and 3B illustrate an embodiment in which three sheets **10a**, **10b**, **10c** are provided in an apparatus **20a** with opposed dies **22a**, **24a** that cooperatively define a die cavity **30a** therebetween, and the sheets **10a**, **10b**, **10** are diffusion bonded (e.g., to form diffusion bonds **54**) that define internal spaces that are inflated, such as in the formation of an expanded honeycomb structure. *See* paragraph [0025]. Claim 36 further recites that the bonded blanks are heated to within a superplastic forming temperature range of the blanks, and superplastically formed at a forming temperature of less than 1450 °F and at a strain rate of at least about 6×10^{-4} per second to produce the structural member having the predetermined configuration. For example, as shown in Figure 3B, a pressurized fluid can be injected through tubes **32a** and between the sheets **10a**, **10b**, **10c** to inflate the pack and thereby superplastically form the sheets **10a**, **10b**, **10c**. Face sheets **10a**, **10c** are superplastically formed against the respective dies **22a**, **24a**, and the middle sheet **10b** is superplastically formed to a corrugated configuration as determined by the diffusion bonds **54** between the middle sheet **10b** and each of the face sheets **10a**, **10c**. *See* paragraph [0025]. With regard to the recited strain rate of Claim 36, Figure 7 illustrates the true

stress and strain of exemplary structural members **10** during superplastic forming operations in which the members are strained at rates of 6×10^{-4} and 1×10^{-3} per second. As illustrated in Figure 7, the structural members **10** can be superplastically formed at a strain rate greater than 3×10^{-4} per second with a true stress of about 6000 psi or less at a true strain of about 1.1 and at a temperature of less than 1500 °F. By increasing the strain rate at which the structural members **10** are superplastically formed, the forming time for each structural member **10** can be reduced. That is, at a greater strain rate, each structural member **10** can be formed to a desired configuration in less time, resulting in greater throughput of production and more efficient use of the equipment. *See* paragraph [0032].

The remaining dependent Claims 17-23 and 37-42 include features generally corresponding to dependent Claims 2, 4, and 5-12.

CONCLUSION

Applicant respectfully requests consideration of the above summary. Further, for the reasons set forth in the Appeal, Applicant submits that the rejections of Claims 1, 2, 4-12, 16-23, and 36-42 are erroneous and therefore requests reversal of the rejections.

Respectfully submitted,

Nicholas F. Gallo
Registration No. 50,135

CUSTOMER NO. 00826
ALSTON & BIRD LLP
Bank of America Plaza
101 South Tryon Street, Suite 4000
Charlotte, NC 28280-4000
Tel Charlotte Office (704) 444-1000
Fax Charlotte Office (704) 444-1111

ELECTRONICALLY FILED USING THE EFS-WEB ELECTRONIC FILING SYSTEM OF THE UNITED STATES PATENT & TRADEMARK OFFICE ON September 24, 2007.